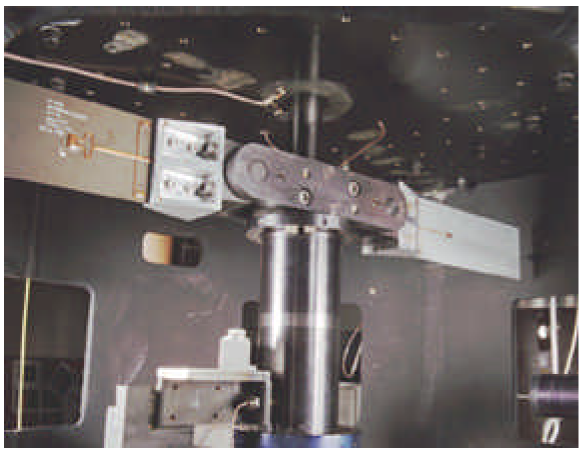
Damping Experiment of Spinning Composite Plates With Embedded Viscoelastic Material

One way to increase gas turbine engine blade reliability and durability is to reduce blade vibration. It is well known that vibration can be reduced by adding damping to metal and composite blade-disk systems. As part of a joint research effort of the NASA Lewis Research Center and the University of California, San Diego, the use of integral viscoelastic damping treatment to reduce the vibration of rotating composite fan blades was investigated. The objectives of this experiment were to verify the structural integrity of composite plates with viscoelastic material patches embedded between composite layers while under large steady forces from spinning, and to measure the damping and natural frequency variation with rotational speed.



Viscoelastic damped composite plates in NASA Lewis' Dynamic Spin Rig.

Data were obtained from in-vacuum vibration spin experiments of flat and twisted graphite composite plates damped with 3M ISD 113 viscoelastic material patches embedded between composite layers. The photograph shows the rotor installation in the spin rig. The rotor has a tip diameter of 792 mm, and the plates have an aspect ratio of 3 and a chord of 76 mm.

Damping was calculated from measured transfer functions of blade base acceleration to blade strain. Damping was repeatable, and there were no failures or delaminations of the plates. This is significant since 3M ISD 113 has a low creep modulus at room temperature, and the plates had a centrifugal load of up to 28,000g at the tip. Centrifugal stiffening was large for the plates and caused a significant drop in the damping ratios, but the viscoelastic material damping remained about constant. Even though the damping ratios decreased, they were always greater than 2 times the damping ratios of undamped control plates. Real fan blades have smaller increases in natural frequencies with rotational speed, and therefore, the decrease in fan blade damping ratio should be smaller than measured in this experiment.

From the results, we concluded that the presence of centrifugal forces, which are well-known to increase blade bending stiffness and corresponding natural frequencies, decreased damping ratios. This phenomenon occurred because as the blade stiffened the percent of modal strain energy in the damping material decreased, thus decreasing the modal damping ratios. To further improve damping, designers will need to consider how to increase the strain energy level in the viscoelastic material, such as using a stiffer viscoelastic damping material than used here. This study reveals not only the potential of integral viscoelastic material damping in composite fan blades, but also illustrates that there are technical challenges that still must be overcome before it can be effectively used as a design option.

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